Climate Change 101 - Human Activities, Emissions, Consequences, Solutions, Two Different Futures

1. Blue Marble

This is a mosaic or a patchwork of satellite images called The Blue Marble. It reminds me of a picture taken of Earth by astronaut William Anders. On Christmas Eve in 1968 during the Apollo 8 mission, a picture was taken of Earth rising over the moon and for the first time Earth was seen as small and fragile, one little planet floating in space. That photo, named "Earthrise," is considered to be the most influential environmental photo ever taken. What I love about this particular view of Earth is that if you were sitting on a GOES satellite, 22,000 miles from the surface of Earth, you would be three Earth radii away and it would look just like this in size and similar in color. Imagine that you could also see the atmosphere off the surface of the sphere.

> **How thick do you think the atmosphere would be? Show me with your hands. (answer: ~1.5cm or a little more than half an inch thick)**
>
> **It's beautiful, don't you think? What words come to *your* mind when you see this image?**

2. Nighttime lights

Perhaps this view of Earth brings different words to mind? We can also look at the whole Earth on SOS as it looks at night. This tells more of a human story. For example, there are some places where a lot of people live, and some places where fewer people live.

> **What do you think powers all these lights?**
>
> In 2022, over 80% of primary energy consumption in the world and over 60% of its electricity was from fossil fuels. Over 70% of the greenhouse gas emissions due to human activity in 2022 was CO2 from burning them.

3. Human Transportation

Take a moment and look at the different colors here and tell me what you think these are.

Red lines represent 87,000 daily flights connecting cities and countries around the world. Blue lines represent the paths of 3,500 commercial vessels over the course of a year, which is only 10% of the total ocean shipping traffic. Green lines represent the world's roads, used by over one billion motor vehicles. This colorful globe shows the interconnected nature of the world, but also shows how much energy we use to move people and goods around the planet's surface.

4. CarbonTracker

Nearly all of those lights we just saw and just about everything we do is tied to fossil fuel – oil, coal and natural gas – extraction and consumption. We have impacted our planet in a dramatic way by digging up carbon and extracting oil that was in the ground for hundreds of millions of years to fuel our modern world and our way of life. Unfortunately, burning fuel puts a lot of carbon dioxide (among other pollutants) into our atmosphere. Carbon dioxide (CO_2) acts like a blanket that surrounds the Earth. More CO_2 in our atmosphere means a thicker blanket that traps more heat.

Here we are looking at carbon dioxide amounts in the atmosphere (not temperature like sometimes red makes us think). When we fast forward through the last decade and a half, that's 15 years, we can see how the carbon dioxide is pooling with almost nowhere to go - remember how small our atmosphere is and the ocean takes on some too. Since the late 1800's we've known that greenhouse gasses, like carbon dioxide, trap heat that would otherwise go back out to space. I think we've figured out what we need to do; the bigger challenge is to take action. Therefore, the planet is heating up and the ocean is acidifying.

5. Temperature Anomaly - 1850 - 2022

In order to see the change in our climate – or our temperature over time – it's best to use an anomaly map, which shows the difference between the current and past temperatures. For example, we have collected the average temperature for each area on the globe for each year from 1850 to now, then we subtract that value from the average temperature of that area on the globe during the 20th century. More simply, if you see white, there is little to no difference. If you see red, it's hotter now than in the past, and where you see blue, it's colder now than in the past. This dataset is a great way to consider the change over a long

period of time – the longest period of time that we have in temperature records. I like to fast forward to the last twenty or so years (starting in 2000).

> **How would you describe what you see? Do you notice any patterns globally? How about where you live?**

This is global warming - the direct effect of increasing carbon dioxide and other greenhouse gasses in our atmosphere. Even though there is still variability in the day to day weather, the overall global trend is toward a warmer world.

6. Drought

A hotter world can have many different effects and these effects often change year to year. Drought is probably one of the most dire effects of climate change because of our need for fresh water for … well, just about everything … growing food, drinking, bathing, recreating …

This is a real-time dataset — meaning that it updates weekly to show the latest data — that highlights the risk of drought globally. Drought risk is considerable in many areas and can change quickly depending on weather conditions. At the same time, warmer conditions dry out soil faster by increasing evaporation. Some places like the Southwest U.S. are particularly prone to drought.

> **How does drought affect *your* community? (consider even how drought far away can affect you, too.)**

7. Sea Ice Extent - September only 1979-Present

Likewise, in a hotter world, ice melts. And unlike drought and precipitation that change year to year, sea ice extent in the Arctic is dramatically decreasing at a pretty steady and unsettling rate. And the worst part about losing ice is the albedo effect, which is a feedback loop. The white from snow and ice on the surface of the planet reflects the sunlight straight back to space but as you can see, the ocean is much darker and absorbs the heat of the sun, therefore, adding more heat to the Earth's system. This dataset shows sea ice extent in September from 1979 to the present.

> **Any idea why September is the month we choose for comparison? [Answer: September is the month that typically has the lowest sea ice extent in the Arctic.]**

8. Climate Model - Surface Temperature Change - SSP5 (Fossil-fueled Development) - 2015 - 2100

As part of the latest Intergovernmental Panel on Climate Change (IPCC) and National Climate Assessment (NCA5) – which are groups and reports that bring together experts from different fields to understand our changing climate – we have been able to visualize the most recent predictions for Earth's future using a framework called Socio Economic Pathways or SSPs. What we are looking at here is the Fossil-fueled Development prediction for global temperature. Similar to the temperature change we looked at minutes ago, this dataset also shows change in temperature as it compares to the average temperature of the 1900s. Red means warmer than the average of the 1900s, blue is colder, and white is roughly no change.

> **If we pause at 2050 and 2100 (that's fast-forwarding to when you all will be [enter advanced ages of whichever age group you're talking to]!) and look at where we live, what do you notice? Now look at the rest of the globe.**

This climate model is deemed the Fossil-fueled Development or SSP5. That means it's showing us what happens in a, sort-of, worst case scenario. In this world, carbon dioxide emissions in 2100 are four times as high as they were in 2000 and there is very little done to reduce emissions. The economy grows dramatically but the human population only grows a little. Of course, this is only a *possible* future.

9. Climate Model - Surface Temperature Change - SSP2 (Middle of the Road) - 2015 - 2100

Another possible future is the Middle of the Road projection. Some climatologists say we are currently on this path.

> **If we pause at 2050 and 2100 and look at where we live, what do you notice? How is this different from the last one we viewed - SSP5-Fossil-fueled Development?**

In this world, CO_2 emissions drop from current levels. Total annual CO_2 emissions in 2100 are half of what they were in the year 2000. Mitigation efforts include low-carbon technology and expanded renewable energy.

10. Solar Power Potential - Monthly Average

There are predictions for the future that are even better than “Middle of the Road (SSP2)”, but we’d have to take full advantage of renewable energies in order to get there. One example is the sun. It’s an incredible source of energy and it is also renewable, because the power from the sun is not depleted or lost by us using it. This dataset visualizes the potential of solar energy for human use for each month of the year. What is shown is a location's ability to generate electricity from sunlight using photovoltaic technology, which is called photovoltaic (PV) power potential. This potential depends on many factors. Sunnier locations naturally have a greater potential for power. The climate also matters. It turns out that photovoltaic panels used to collect the energy from the sun tend to perform better in cooler temperatures.

What other types of renewable energy are you aware of?
Why do you think the PV potential changes from month to month?

11. Resilience Community

Ok, enough doom and gloom. The fact is, humanity has ALL the tools and resources needed to solve this global crisis. We just have to get to work.

Take a look at this community. What’s going on here? Or what do you notice about what a resilient community looks like?

Do these activities seem doable? Have you done things like this before in your community?

12. Climate Model - Surface Temperature Change - SSP1 (Sustainability) - 2015 - 2100

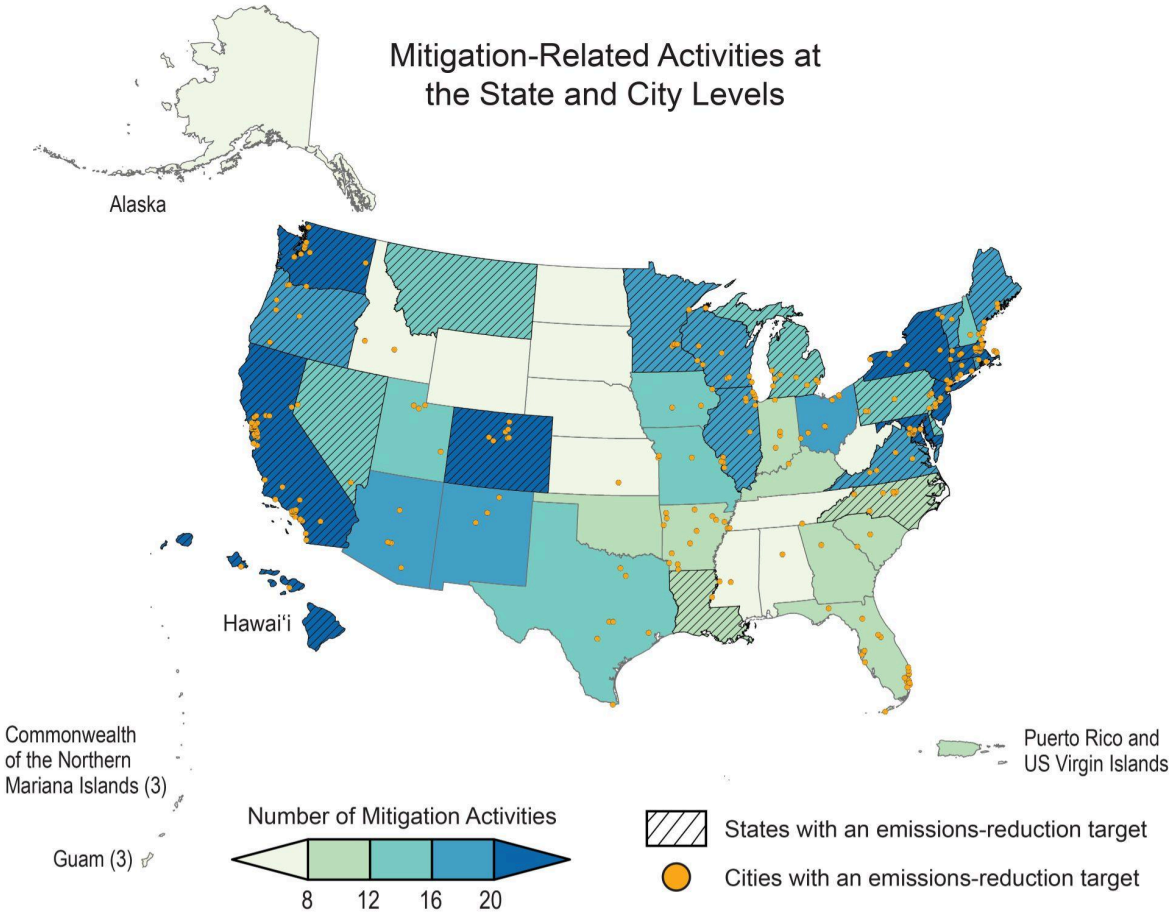
If we figured out how to tap into wind and geothermal renewable energy in addition to solar and moved away from fossil fuels completely, perhaps this is the world we would have.

Q: If we pause at 2050 and 2100 and look at where we live, what do you notice? How is this different from the last one we viewed - Middle of the Road?

13. Mitigation and Resilience

We are hard at work in this and other countries, but everyone has to play their part. Here is a map of the mitigation-related activities at the U.S. state and city levels to 2022. Get involved in your local community and see what is already going on. NOAA funds community resilience programs, for example, the Environmental Literacy Program promotes action like the images shown here.

What activities have you been involved in or want to get involved in that might help your community to be resilient?



Suggested Educational Materials

- Climate Literacy and Energy Awareness Network (CLEAN): Teaching Climate and Energy - Principle 5
- Climate Interactives - Climate Change Solutions Simulators
- Climate Literacy and Energy Awareness Network (CLEAN): Webinar Series
- Climate Literacy and Energy Awareness Network (CLEAN): Climate Model Resource Collection
- Data Puzzles - CIRES Education and Outreach
- Antarctica: Connecting Climate Change, Melting Ice Shelves, and Pooping Penguins - CIRES Education and Outreach
- Arctic Feedbacks - Not All Warming Is Equal - CIRES Education and OutreachClimate and Resiliency Education - CIRES Education and Outreach